DRI TECHNICAL PROGRAM: Emerging Dynamics Of The Marginal Ice Zone

Ice, Ocean and Atmosphere Interactions in the Arctic Marginal Ice Zone

Year 3 Annual Report

Jeremy Wilkinson
British Antarctic Survey
phone: 44 (0)1223 221489 fax: 44 (0) 1223 362616
email: jpw28@bas.ac.uk
http://www.bas.ac.uk

Co-PRINCIPAL INVESTIGATOR:
Ted Maksym
Woods Hole Oceanographic Institution
tmaksym@whoi.edu

Co-PRINCIPAL INVESTIGATOR:
Byongjun (Phil) Hwang
The Scottish Association for Marine Science
Phil.Hwang@sams.ac.uk

LONG-TERM GOALS

This DRI TECHNICAL PROGRAM (Emerging Dynamics Of The Marginal Ice Zone) brings together a high-level (global) scientific team in order to better understand the ocean, sea ice and atmosphere interaction within the marginal ice zone (MIZ) north of Alaska. The aim of this multi-disciplinary group is to deliver a step change in our understanding of the processes within the MIZ. This is being achieved through a comprehensive, and continuous observational program of the key physical parameters that influence the development of the MIZ. Our long-term goal is to determine the complex inter-linkages between atmosphere-ice-ocean processes so that, ultimately, parameterisations of MIZ processes can be developed for large-scale models.

OBJECTIVES

Our team's role in this DRI is to better understand the ice-ocean-interactions within the MIZ. This is being achieved through the deployment (2014) an autonomous data acquisition network of ice mass balance buoys (IMBs), wave buoys (WBs), and Automatic Weather Stations (AWS) in the region north of Alaska. The now deployed arrays have a number of roles within our project, with the main priorities being:

(a) the dynamic and thermodynamic evolution of the ice covers,
(b) the development of the wave properties from open-ocean into the ice pack, and
(c) the seasonal evolution of key meteorological parameters and
(d) the continuous measurement of open water fraction and floe size distribution over the network/array region SAR remote sensing programme.

The strategy of using the combination of autonomous platforms and remote sensing ensures the full temporal evolution of the ice cover is monitored continuously from its initial break-up, through to its transformation to a MIZ and then the northward retreat of the ice edge. Through the long-term measurement of the key oceanic, atmospheric, and sea ice processes that shape the MIZ, the links and feedbacks between each can be determined and their importance at different stages in the MIZ cycle established. Our observations link with the corresponding oceanic observations and modelling efforts that the DRI-MIZ community are making.

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Year 1 objectives:

- Integrate our science into the DRI science plan.
    - Result: COMPLETED
- Begin design of IMB/wave buoy electronics.
    - Result: COMPLETED
- Test first prototype electronics under Arctic conditions:
    - Result: COMPLETED

Year 2 objectives:

- Finalise WaveBuoy (WB) design.
    - Result: COMPLETED
- Build and deploy three prototype WBs in the Arctic
    - Result: COMPLETED
- Begin build of Ice Mass Balance Buoys (IMBs), WBs and automatic weather stations (AWSs)
    - Result: Build started
- Consolidate work with the DRI team
    - Result: COMPLETED

Year 3 objectives:

- Ship and deploy 20 xWBs, 20 x IMBs, 4 x AWSs for Spring campaign.
    - Result: COMPLETED
- Ice Camp planning and participation
    - Result: COMPLETED
- Ship and deploy 5 xWBs, 5 x IMBs, 1 x AWSs for Summer campaign.
    - Result: COMPLETED
- Araon cruise: planning and participation
    - Result: COMPLETED
- Plan and collect remote sensing imagery
    - Result: ON-GOING
- Quality control and analyse both buoy and remotely sensed data
    - Result: ON-GOING
- Consolidate work with the DRI team and begin interpretation of data.
    - Result: ON-GOING

APPROACH

Staff Involved:

PRINCIPAL INVESTIGATOR:
Jeremy Wilkinson
British Antarctic Survey
jpw28@bas.ac.uk

Co-PRINCIPAL INVESTIGATOR:
Ted Maksym
Woods Hole Oceanographic Institution
tmaksym@whoi.edu

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Byongjun (Phil) Hwang
The Scottish Association for Marine Science
Phil.Hwang@sams.ac.uk

WORK COMPLETED

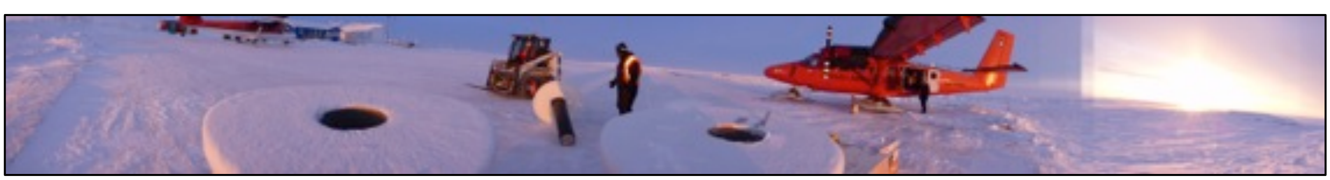
Our third year built on the solid foundation we developed within year 1 and year 2 of the project. We can summarise this year's achievements into four areas:

1. Logistic success: The logistic successes cover both the Spring MIZ ice camp (Wilkinson and Maksym) and the Summer cruise of *Araon* (Hwang). The many internal meetings with key personnel at BAS, the regular internal Skype meetings between BAS, SAMS and WHOI, as well external teleconferences and meetings with UW, other MIZ team members, and KOPRI all contributed to the success of these campaigns. The tight working relationship of all involved overcame the spatial separation of the institutes and ensured the efficient and safe mobilisation of personnel, and the successful deployment of all the equipment.

2. KOPRI success: A key component of the successful KOPRI-MIZ collaboration was the extensive groundwork that was performed by all Parties. Discussions included meetings at KOPRI as well as liaising with the members of the ONR DRI team and ONR itself. Our team played a proactive role is this with Hwang being a significant contact between KOPRI and the ONR team.

3. Deployment successes: This work covers the three buoy systems (IMBs, WBs, and AWSs), as well as the web interface that has been designed to both visualise and download the data. The development of these systems was a collaborative effort between our three institutes, the Wadham's team (for the WBs) and Bruchin (for the web interface). To date all systems have worked extremely well. As of 1 September we had 15 (of the 20) WBs, 12 (of the 20) IMBs, and 2 (of the 4) AWSs still active from the original Spring deployment.

4. Remote sensing successes: The team played a key role in the development of the remote sensing plan for the MIZ, and participated (Wilkinson) in the weekly planning on the RS products through the Acquisition Team. Throughout the season Hwang has been successfully acquiring SAR imagery over the buoy array in order to complement those products being obtained by other means.



RESULTS

1. Logistics:

The team contributed to the "ONR-MIZ Field Manual: March-April 2014". This manual ensured that all participants were aware of the logistic plans, health and safety, instrument deployment operations, as well as our communication and flight schedules. BAS were closely involved in the Spring field programme, as one of their planes was charted for this programme.

Through Hwang's close historical ties with KOPRI he was able to brief and advise MIZ participants regarding the Summer cruise of the *Araon*.

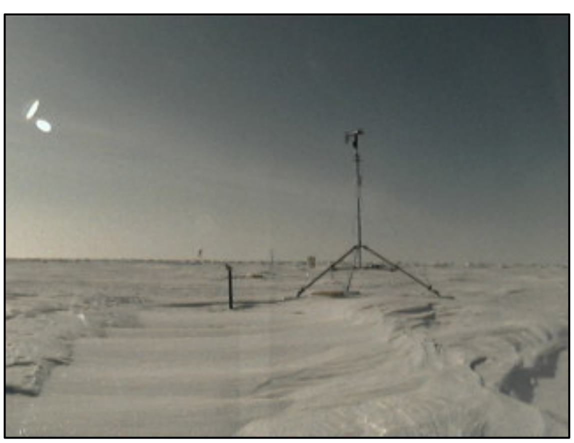
2. KOPRI integration:

Our team has been involved in the negotiations between KOPRI and ONR. This includes meetings at KOPRI and liaising with the members of the ONR DRI team, and ONR itself. Hwang is playing a crucial role as one of the main contacts between KOPRI and the ONR team. A significant behind the scene effort by Hwang (and others) was needed to ensure both KOPRI and ONR-MIZ were on the same page.

3 Deployment:

Spring MIZ deployment

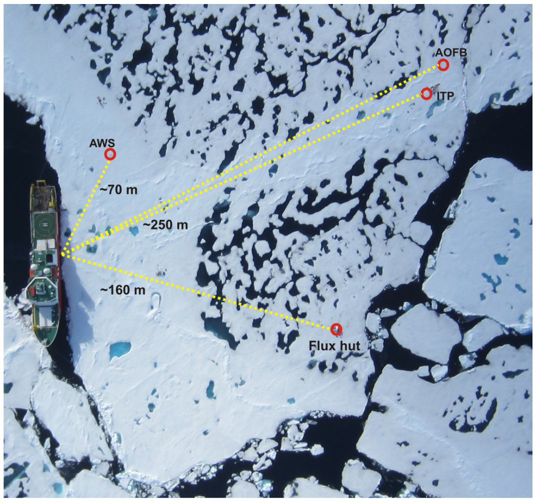
During the spring MIZ deployment we (Maksym/Wilkinson) contributed to the deployment of 20 x WBs, 20 x IMBs, 4 x AWSs. These assets were deployed across the four clusters (C1, C2, C3, and C4) in a five-dice array pattern. The distance between the buoys that made up the outside of the array was about 5 km. At the centre of each array was a WB, AWS, and IMB, whilst at each corner of the array there was a WB and an IMB installed. Where possible we tried to face the camera of the WB in a southward direction and ensure that any instrumentation deployed on the ice was within the field of view of the camera. The following picture is from WB09 on 1 May and 3 September. For more details on Ice Camp deployment refer to Field Report

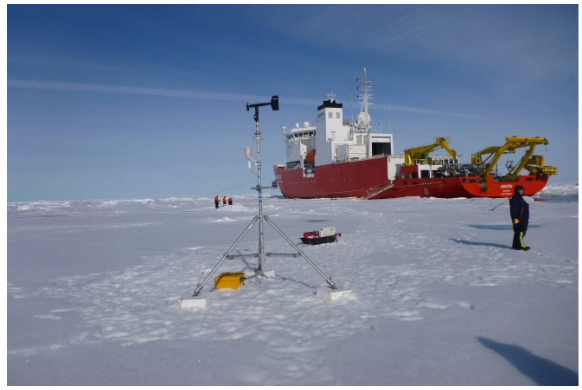


Summer: Araon

During Summer *Araon* cruise, Hwang deployed 5x IMBs and 1x AWS, and assisted with other MIZ buoy deployments (WBs, ITPs and AOFB) and operations (Flux measurement). These buoys formed the backbone of Cluster 5.

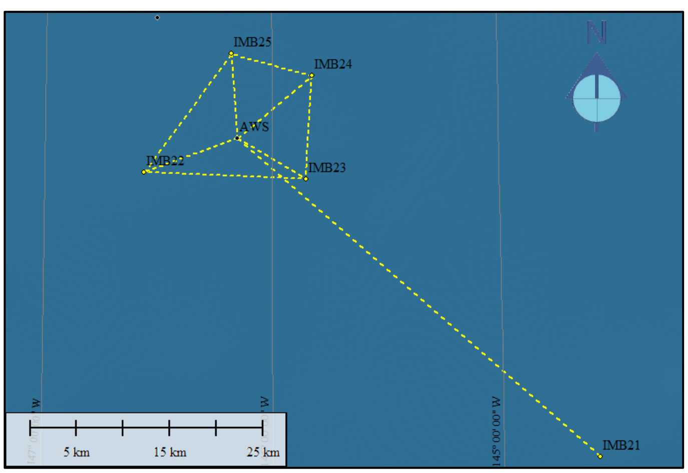
The site selection for the KOPRI-MIZ ice camp was made based on the location of MIZ clusters 3 and 4, as well as local ice conditions. The selected MIZ ice camp (77° 36.15′ N / 146° 05.04′ W) was located about 300 km north from in-between MIZ clusters 3 and 4.





Deployment location of MIZ assets at the MIZ ice camp (left). Photo of AWS deployed at the ice camp

During the 6-day ice camp 1x AWS was deployed along with ITP and AOFB buoys on the same ice floe (Fig above). 4x IMBs were deployed about 10-15 km from the ice camp location, and 1x IMB (IMB 21) was deployed 50-km southwest from the ice camp (Fig. below). For more details on Summer *Araon* deployment refer to Cruise Report (IBRV *Araon* ARA05B, July30-August25, 2014, by KOPRI).



Location of five IMBs on August 14 2014. The center of the buoy array is the location of the MIZ ice camp (left). Photos of IMB deployment (right).

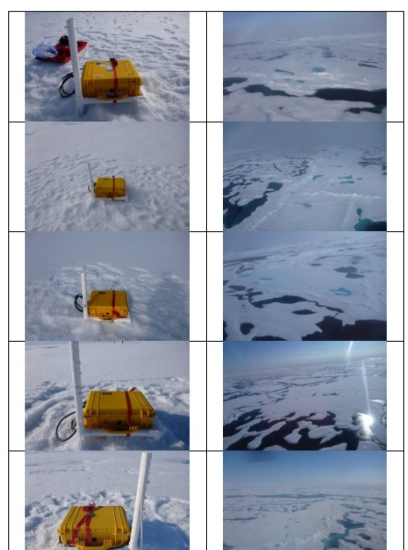


Fig. 11.7. (top to bottom) Deployment photos of IMBs 21, 22, 23, 24 and 25.

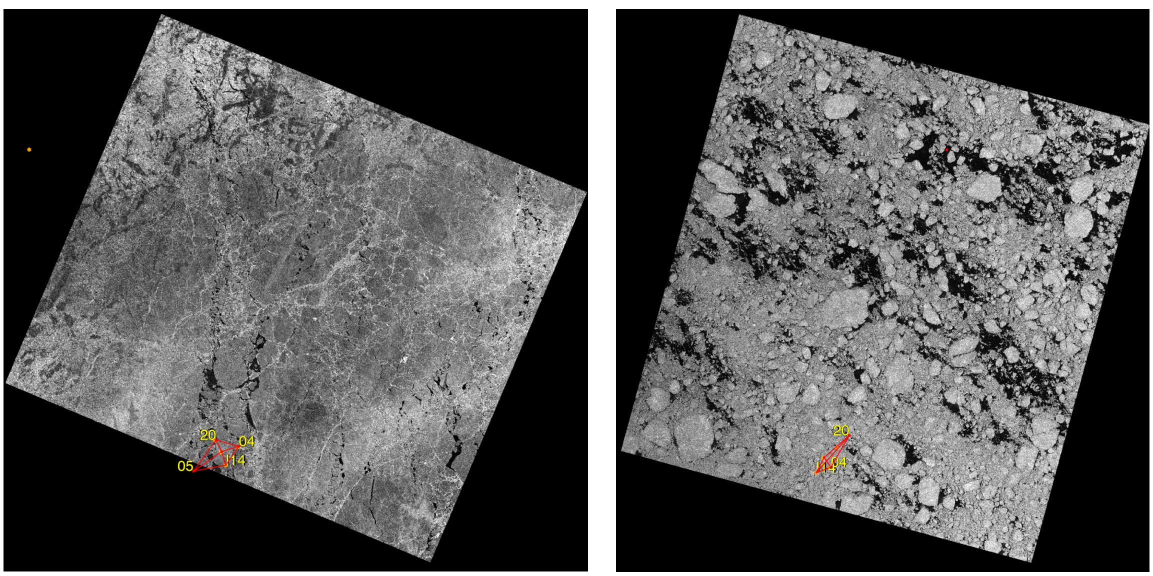
Taken as a whole the transmitted data from the WBs, IMBs and AWSs have contributed to the following information:

- Over 30 gigabytes wave information
- Over 150 megabytes of sea ice mass balance information
- Almost 3 megabytes of meteorological data.

4. Remote sensing:

All five MIZ buoy clusters were well captured by satellite imagery. The SAR images acquired by Graber are 61 x Radarsat-2 images and more than 400 x TerraSAR-X images. Hwang acquired more than 30 additional TerraSAR-X images.

Radarsat-2 images, ScanSAR Wide (SCW), offer pixel spacing of 50 m and swath size of 500 by 500 km. The TerraSAR-X images acquired by Graber are mainly Single-Pol StripMap mode that offers pixel spacing of about 3 m and swath size of 30 by 50 km. TerraSAR-X images acquired by Hwang are mainly ScanSAR 4-beam mode that offer pixel spacing of about 8 m and swath size of 100 km by 150 km. We will mainly focus on TerraSAR-X images to obtain floe size distribution. Examples of TerraSAR-X ScanSAR images acquired on June and August at MIZ cluster 4, exhibiting deterioration of ice floes for two month period.



TerraSAR-X ScanSAR images acquired on June 10 (left) and August 10 (right). The red lines with yellow letters indicate the location of WBs at the time of image acquisition.

Note: It has been a challenge to find available acquisition swath for TerraSAR-X images for our area of interest. It seems that other users, at this location and time, have heavily used the TerraSAR-X satellite.

Additional Achievements

- We are just starting the analysis phase of this programme. To this end we are presently going through the QC procedures.
- The exceptional survivability of our systems suggests that they are now able to contribute to the Sea State DRI. For example in October, 2015, the Sikuliaq will be in the Beaufort/Chukchi to observe the ice advance. Key goals are to monitor the sea state outside the ice edge, but also ice-wave interactions. A major part of the field campaign is to look at the evolution of the autumn ice cover and whether the seasonal evolution has changed regimes with the large increase in open water at the start of Autumn. Having information on the state of the ice cover from surviving platforms in Autumn 2014, we imagine, will be very helpful.

IMPACT/APPLICATIONS
[Potential future impact for science and/or systems applications]
N/A at present.

TRANSITIONS
N/A at present.

RELATED PROJECTS
- ACCESS: EU FP 7 funded programme
- ICE-ARC EU FP7 funded programme
- DRI-Sea State
- USCG Arctic Shield
- UK NERC funded programme

REFERENCES
N/A

PUBLICATIONS
N/A

PATENTS
N/A

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N/A